AEC-NASA TECH BRIEF

Surface Profilometer for Examining Grain-Boundary Grooves

The problem:

To develop an accurate and precise technique for measuring topographical features on the surfaces of solids. The most accurate and commonly used technique for this purpose has been interference microscopy. This technique, however, requires corrections for illumination conditions, and the profile of a surface feature is greatly exaggerated in the vertical direction; thus the accuracy of the technique is unsatisfactory for measurement of profiles such as grain-boundary grooves in which the width-to-depth ratio is roughly 10:1 or less.

The solution:

A surface profilometer, consisting primarily of commercially available components, measures surface topographical features accurately and precisely. The apparatus permits horizontal magnification by roughly 10,000× and vertical magnification by 100,000×, and can give a 1:1 ratio at 10,000× or more. Application of the technique to grain-boundary grooves formed during annealing on nickel-oxide bicrystals indicates that it improves by at least an order of magnitude the measurement of shape and size of groove profiles by the commonly used interferometric technique.

How it's done:

A diamond stylus having a radius of about 1 μm traverses the surface of the sample, and its vertical deflection and horizontal movement are measured electrically. The primary component is a surface profilometer including a parallel datum attachment. This unit was originally designed to inspect surface finishes of machined parts; it has also been used to measure thicknesses of thin films for microcircuit applications. The available unit is capable of only 500× horizontal magnification; thus a linear strain-gage transducer, with a total travel of 0.12 mm, is used to measure horizontal displacement of the stylus arm.

The output of the profilometer is the input for the y-axis of an x-y recorder; that of the strain-gage transducer, for the x-axis. The output of both the profilometer and the linear transducer is 5 v full scale, which provides almost infinite magnification on the most sensitive range of the recorder (0.1 mv/inch). However, the mechanical limitation of vibration, sample positioning, calibration, and instabilities in the traversing motion of the stylus place the upper practical limit on both x and y magnifications at roughly 100,000×. The magnified profile of the surface is conveniently reproduced on 8½-by-11-inch graph paper.

The apparatus has been further modified to provide manual traversing of the stylus arm by means of a 600:1 speed-reducer and a handwheel. This change adds the flexibility of traversing both forward and backward across the surface feature, and simplifies positioning of the stylus at the desired point on the surface of the sample. The fact that the sample is mounted on a two-axis micrometer translation stage having a total travel of 0.5 inch and a sensitivity of 0.0001 inch in both directions further aids positioning of the sample. This micrometer stage also allows traversing along the length of a surface feature, such as a grain-boundary groove, to obtain profiles, at various positions, giving a three-dimensional profile of the groove. The strain-gage trans-

(continued overleaf)

ducer is mounted on a single-axis translation stage having a total travel of 0.05 inch and a sensitivity of 5 microinches. This allows accurate zeroing and centering of the profile on the recorder, and enables calibration of the x-traverse. The vertical calibration is obtained from standards provided with the profilometer. Finally, to reduce vibration, the apparatus is mounted on a granite tabletop supported by air pistons.

Reference:

For more detail see D. W. Ready and R. E. Jech, *J. Amer. Ceram. Soc.* **51** (4) (April 1968).

Notes:

1. This information may be of interest in the fields of metallurgy, mineralography, electronics, and ceramics.
2. Inquiries may be directed to:

   Office of Industrial Cooperation
   Argonne National Laboratory
   9700 South Cass Avenue
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   Reference: B69-10345

Source: D. W. Ready and R. E. Jech
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Patent status:

Inquiries concerning rights for commercial use of this innovation may be made to:

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